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Related Pending Application

Related Case Serial No: 09/944,075

Related Case Filing Date: 09-04-01

WHAT IS CLAIMED IS:

1. A magnetoresistance effect element comprising:
 - two ferromagnetic layers, one of the two ferromagnetic layers being a magnetization fixed layer having a magnetization direction substantially fixed to one direction, and the other ferromagnetic layer being a magnetization free layer having a magnetization direction varying in response to an external magnetic field;
 - a non-magnetic layer provided between the ferromagnetic layers; and
 - a layer containing an oxide or nitride as a principal component containing a magnetic transition metal element which does not bond to oxygen and nitrogen and which is at least one of Co, Fe and Ni,the magnetoresistance effect element having a resistance varying in response to a relative angle between the magnetization direction of the magnetization fixed layer and the magnetization direction of the magnetization free layer.
2. A magnetoresistance effect element as set forth in claim 1, wherein the layer containing the oxide or nitride as the principal component contains a magnetic transition metal element of Co which does not bond to oxygen and nitrogen.
3. A magnetoresistance effect element as set forth in claim 1, wherein a thickness of the layer containing the oxide or nitride as the principal component is in the range of from 1 nm to 3 nm.
4. A magnetoresistance effect element as set forth in claim 1, wherein the layer containing the oxide or nitride as the principal component contains an oxide or nitride of any one of Fe, Co, Ni, Mn, Cr, V, Ti, Zr, Mo, Hf, Ta, W and Al.
5. A magnetoresistance effect element as set forth in claim 1, wherein the magnetization fixed layer comprises a plurality of stacked layers, and the layer containing the oxide or nitride as the principal component is provided between layers

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constituting the magnetization fixed layer.

6. A magnetoresistance effect element as set forth in claim 5, wherein a thickness of the layer constituting the magnetization fixed layer between the non-magnetic layer and the layer containing the oxide or nitride as the principal component is in the range of from 1 nm to 3 nm.

7. A magnetoresistance effect element as set forth in claim 1, wherein the magnetization fixed layer comprises: a layer having a magnetization direction substantially fixed to one direction; a second non-magnetic layer; and a third ferromagnetic layer antiferromagnetically bonding to the layer having the magnetization direction substantially fixed to one direction, via the second non-magnetic layer.

8. A magnetoresistance effect element as set forth in claim 1, wherein the layer having the oxide or nitride as the principal component contacts an opposite surface of the magnetization free layer to the non-magnetic layer via the second non-magnetic layer.

9. A magnetoresistance effect element as set forth in claim 8, wherein a total thickness of the magnetization free layer and the second non-magnetic layer is in the range of from 2 nm to 4 nm.

10. A magnetoresistance effect element as set forth in claim 1, wherein an atomic composition of at least one of argon, xenon, helium, krypton and neon contained in the layer containing the oxide or nitride as the principal component is twice or more as much as the atomic composition of that in the layer which contacts the layer containing the oxide or nitride as the principal component.

11. A magnetoresistance effect element comprising:
a magnetization fixed layer having a ferromagnetic layer having a magnetization direction substantially fixed to one

direction;

a magnetization free layer having a ferromagnetic layer having a magnetization direction varying in response to an external magnetic field;

a non-magnetic intermediate layer provided between the magnetization fixed layer and the magnetization free layer;

a high conductive layer having a higher conductivity than those of the magnetization fixed layer and the magnetization free layer, being stacked on one side of the magnetization free layer remoter from the non-magnetic intermediate layer; and

a non-magnetic crystalline layer provided on one side of the high conductive layer remoter from the magnetization free layer, and containing a compound of an element, which is different from the principal element constituting the high conductive layer, as a principal component, the non-magnetic crystalline layer having a substantially non-magnetism and being substantially crystalline.

12. A magnetoresistance effect element as set forth in claim 11, wherein the non-magnetic crystalline layer contains at least one of oxides of B, Si, Ge, W, Nb, Mo, P, V, Sb, Zr, Ti, Zn, Pb, Cr, Sn, Ga, Fe, Co and rare earth metals.

13. A magnetoresistance effect element as set forth in claim 11, wherein a thickness of the non-magnetic crystalline layer is in the range of from 0.5 nm to 5 nm.

14. A magnetoresistance effect element as set forth in claim 11, wherein a thickness of the high conductive layer is in the range of from 0.5 nm to 3 nm.

15. A magnetoresistance effect element comprising:

a magnetization fixed layer having a ferromagnetic layer having a magnetization direction substantially fixed to one direction;

a magnetization free layer having a ferromagnetic layer having a magnetization direction varying in response to an

external magnetic field;

a non-magnetic intermediate layer provided between the magnetization fixed layer and the magnetization free layer;

a high conductive layer having a higher conductivity than those of the magnetization fixed layer and the magnetization free layer, being stacked on one side of the magnetization free layer remoter from the non-magnetic intermediate layer;

a first compound layer provided on one side of the high conductive layer remoter from the magnetization free layer, and containing an oxide of an element, which is different from the principal element constituting the high conductive layer, as a principal component; and

a second compound layer provided on one side of the first compound layer remoter from the high conductive layer.

16. A magnetoresistance effect element as set forth in claim 15, wherein the first compound layer contains an oxide of a first element selected from a ranking of elements consisting of B, Si, Ge, Ta, W, Nb, Al, Mo, P, V, As, Sb, Zr, Ti, Zn, Pb, Th, Be, Cd, Sc, La, Y, Pr, Cr, Sn, Ga, Cu, In, Rh, Pd, Mg, Li, Ba, Ca, Sr, Mn, Fe, Co, Ni, and Rb, as a principal component and

the second compound layer contains an oxide of an element of the ranking of elements arranged after the first element, as a principal component.

17. A magnetoresistance effect element as set forth in claim 15, wherein a total thickness of the first compound layer and the second compound layer is in the range of from 0.5 nm to 5 nm.

18. A magnetoresistance effect element as set forth in claim 11, wherein a thickness of the high conductive layer is in the range of from 0.5 nm to 3 nm.

19. A magnetoresistance effect element comprising:

a magnetization fixed layer having a ferromagnetic layer having a magnetization direction substantially fixed to one

direction;

a magnetization free layer having a ferromagnetic layer having a magnetization direction varying in response to an external magnetic field;

a non-magnetic intermediate layer provided between the magnetization fixed layer and the magnetization free layer;

a high conductive layer having a higher conductivity than those of the magnetization fixed layer and the magnetization free layer, the high conductive layer being stacked on one side of the magnetization free layer remoter from the non-magnetic intermediate layer, and

a layer containing an oxide of an element different from the principal element constituting the high conductive layer, as a principal component, and being formed by the irradiation with an ionized gas and stacked on the high conductive layer.

20. A magnetoresistance effect element comprising:

a magnetization fixed layer having a ferromagnetic layer having a magnetization direction substantially fixed to one direction;

a magnetization free layer having a ferromagnetic layer having a magnetization direction varying in response to an external magnetic field;

a non-magnetic intermediate layer provided between the magnetization fixed layer and the magnetization free layer;

a high conductive layer having a higher conductivity than those of the magnetization fixed layer and the magnetization free layer, the high conductive layer being stacked on one side of the magnetization free layer remoter from the non-magnetic intermediate layer; and

a layer containing an oxide of an element different from the principal element constituting the high conductive layer, as a principal component, and being formed by the irradiation with a plasma gas and stacked on the high conductive layer.

ABSTRACT OF THE DISCLOSURE

There are provided a magnetoresistance effect element, a magnetic head, a magnetic head assembly and a magnetic recording system, which have high sensitivity and high reliability. The magnetoresistance effect element has two ferromagnetic layers, a non-magnetic layer provided between the ferromagnetic layers, and a layer containing an oxide or nitride as a principal component, wherein the layer containing the oxide or nitride as the principal component contains a magnetic transition metal element which does not bond to oxygen and nitrogen and which is at least one of Co, Fe and Ni.

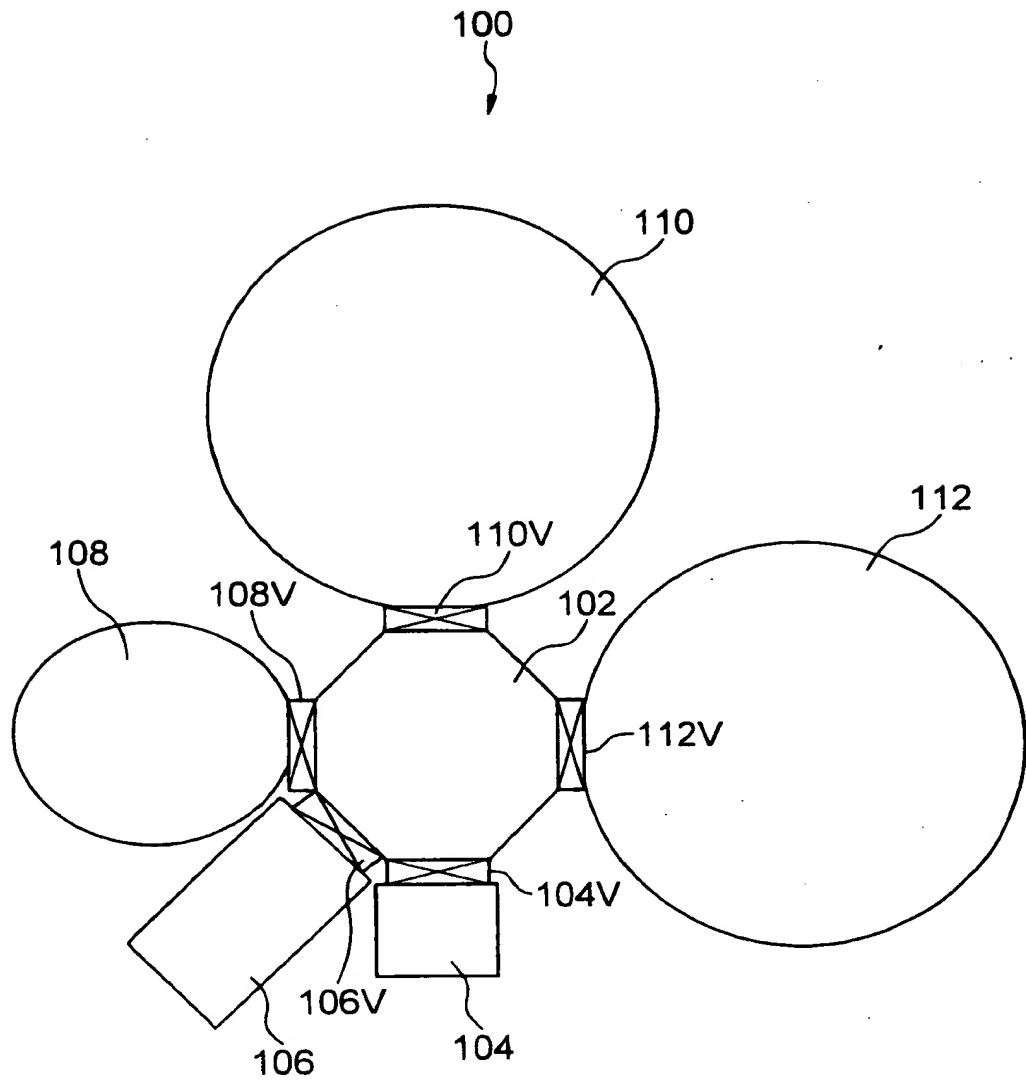


FIG. 1



FIG. 2

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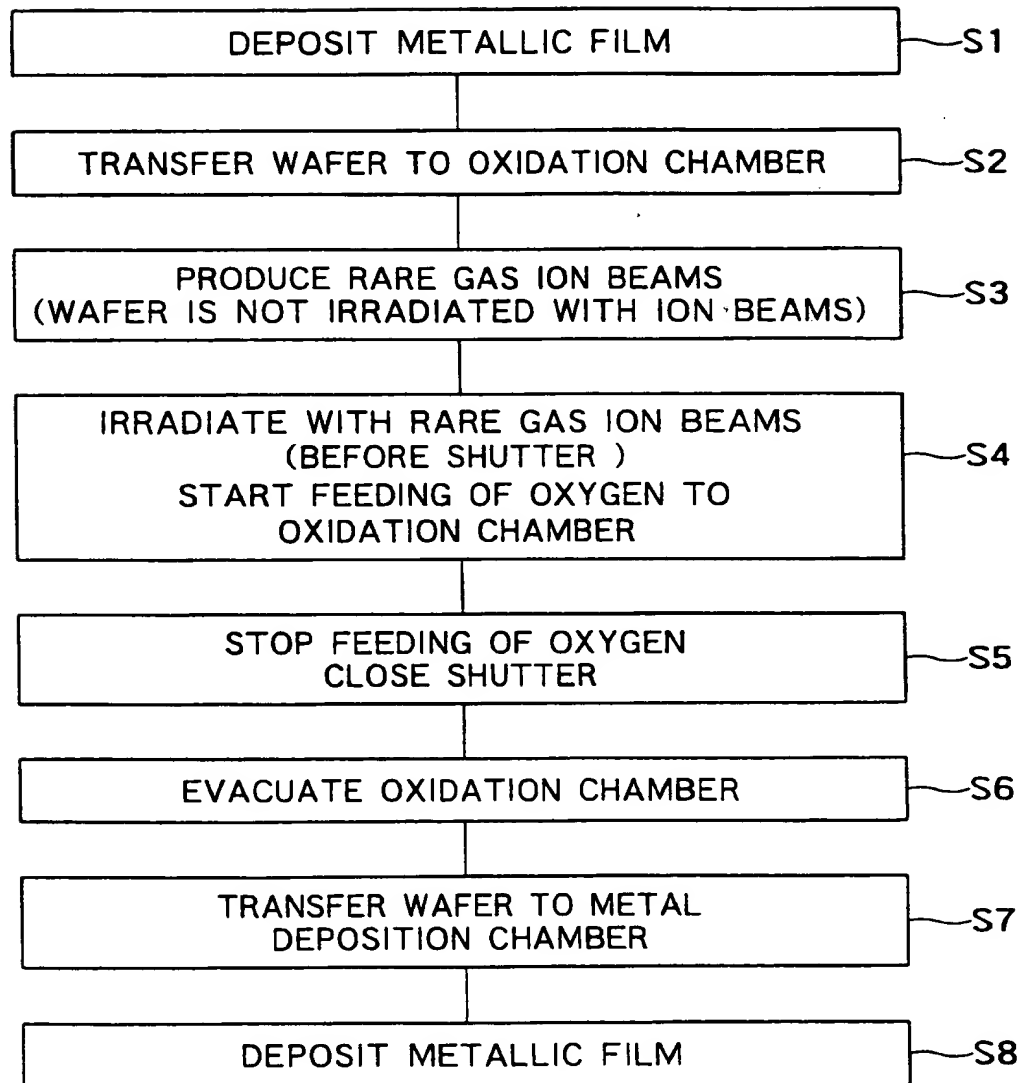


FIG. 3

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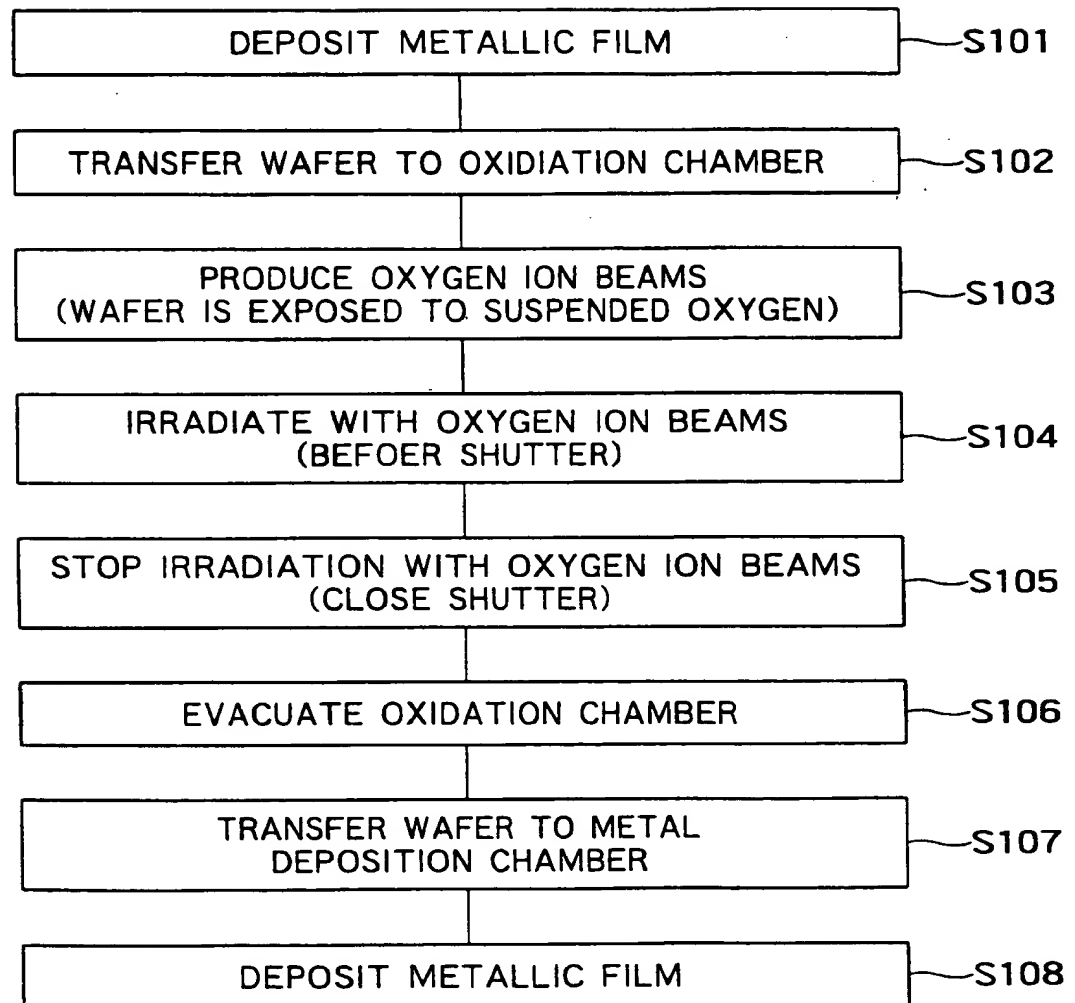


FIG. 4

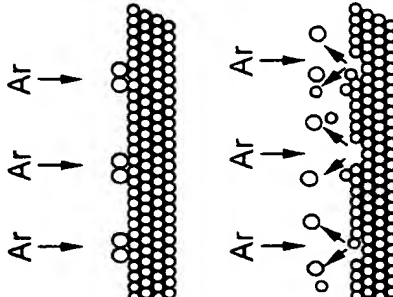
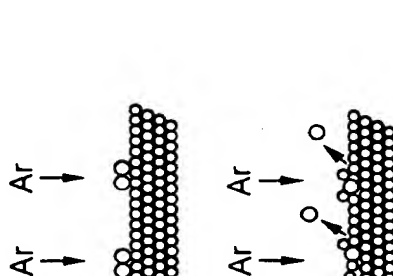
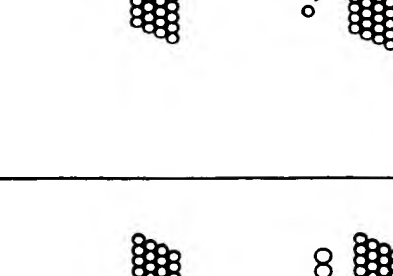
(a)	(b)	(c)
<p>SMALL Ar ENERGY (NO METAL MILLING EFFECT) $V_a \sim 50\text{eV}$</p>	<p>OPTIMUM Ar ENERGY (METAL MILLING EFFECT EXISTS) $V_a \sim 100\text{eV}$</p>	<p>MAXIMUM Ar ENERGY (LARGE METAL MILLING EFFECT) $V_a \sim 150\text{eV}$</p>
		
<p>ONLY DESORB OXYGEN ABSORBED INTO SURFACE OF FILM BY IRRADIATION WITH Ar</p> <p>↓</p> <p>OXIDATION REACTION NOT HAPPEN</p>	<p>CUT BONDING TO SURFACE METAL BY IRRADIATION WITH Ar TO MAKE ACTIVE SURFACE TO PROMOTE RE-BONDING TO OXYGEN</p> <p>↓</p> <p>NO SUSPENDED OXYGEN, STABLE OXIDE IS FORMED</p>	<p>STRONG MILLING EFFECT BY IRRADIATION WITH Ar</p> <p>↓</p> <p>SURFACE OF METAL IS SCRAPED WITHOUT FORMING OXIDE</p>

FIG. 5

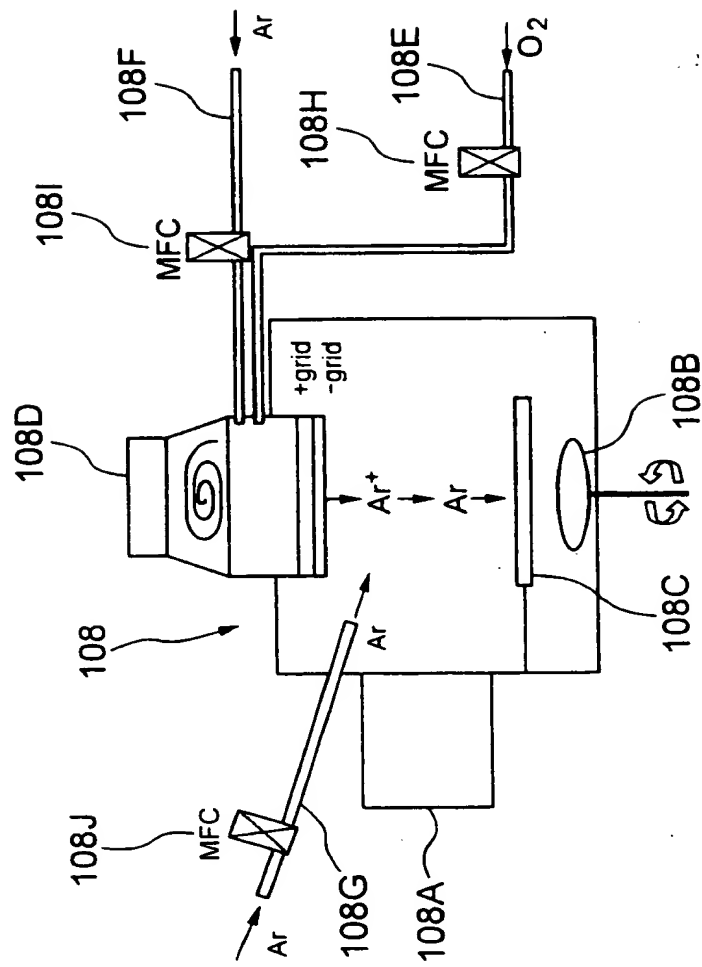


FIG. 6

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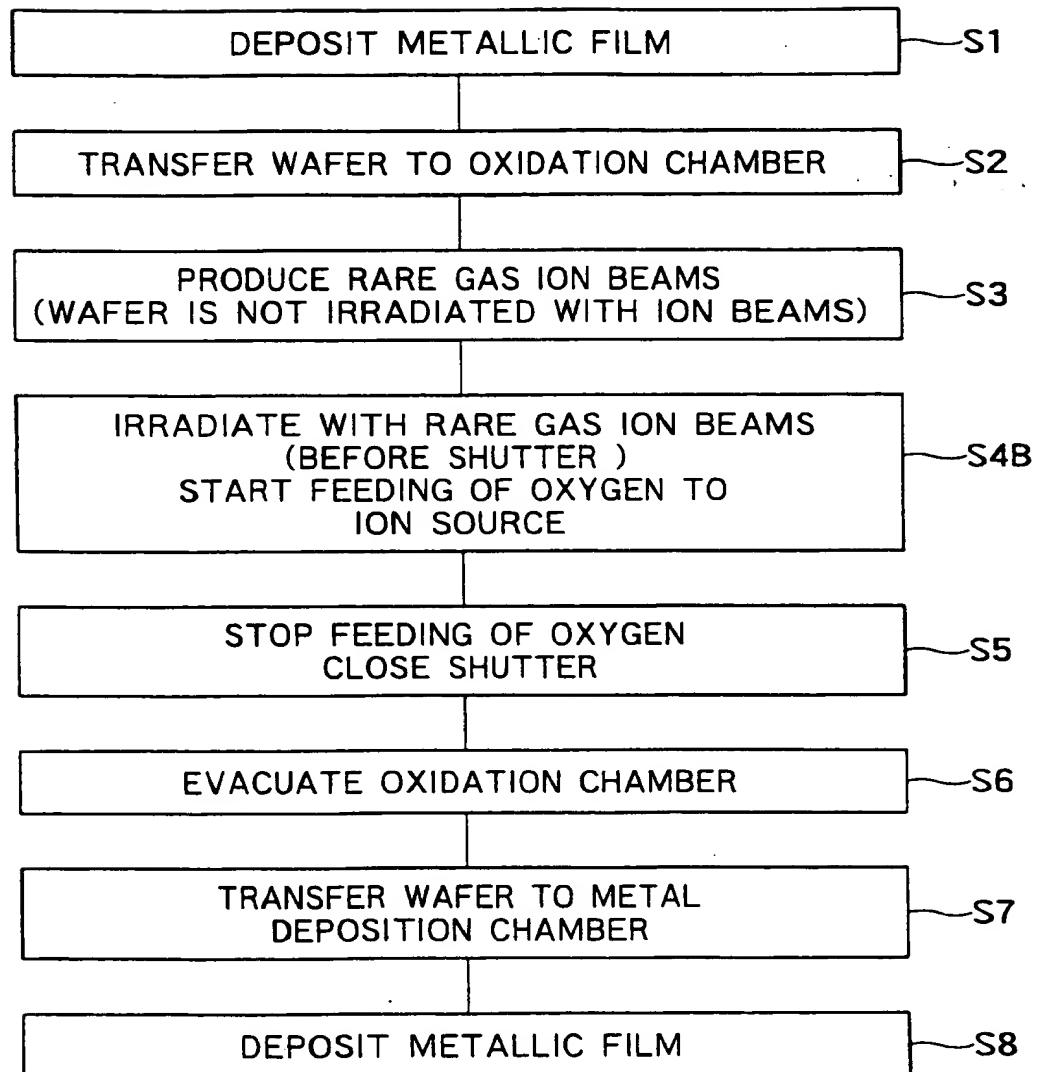


FIG. 7

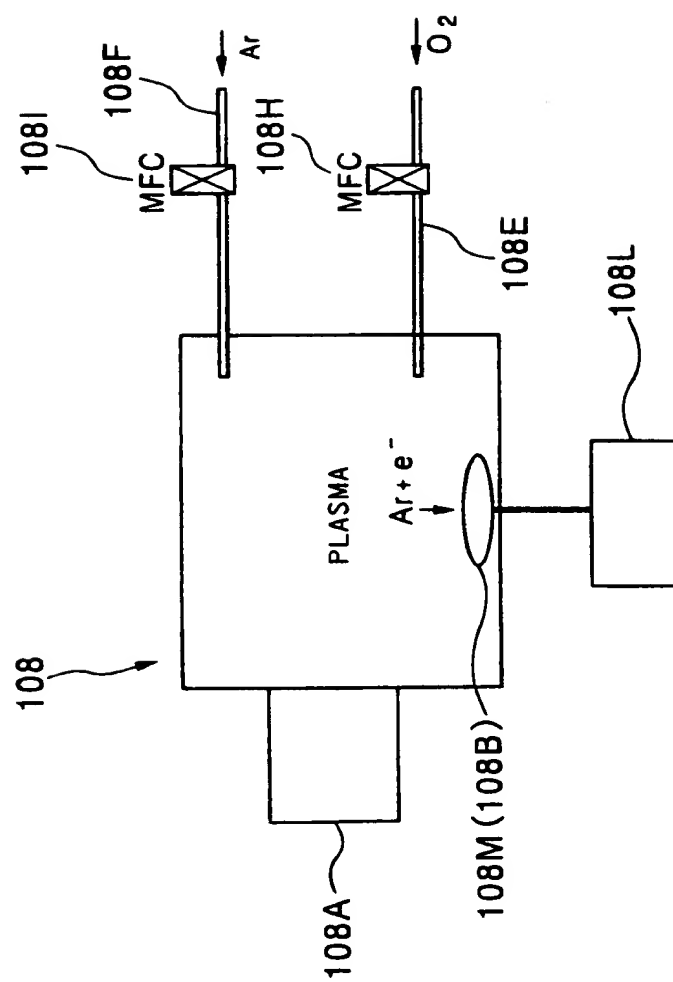


FIG. 8

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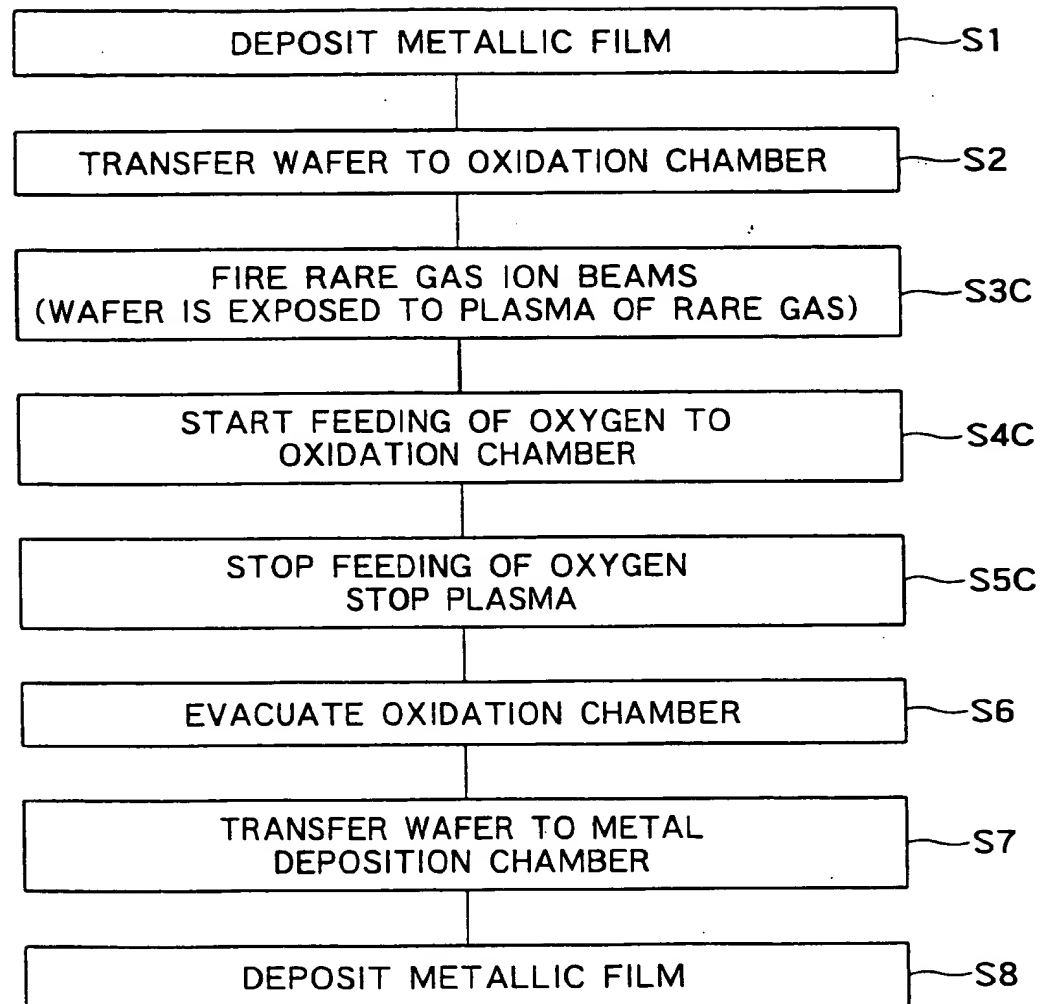


FIG. 9

FIG. 10

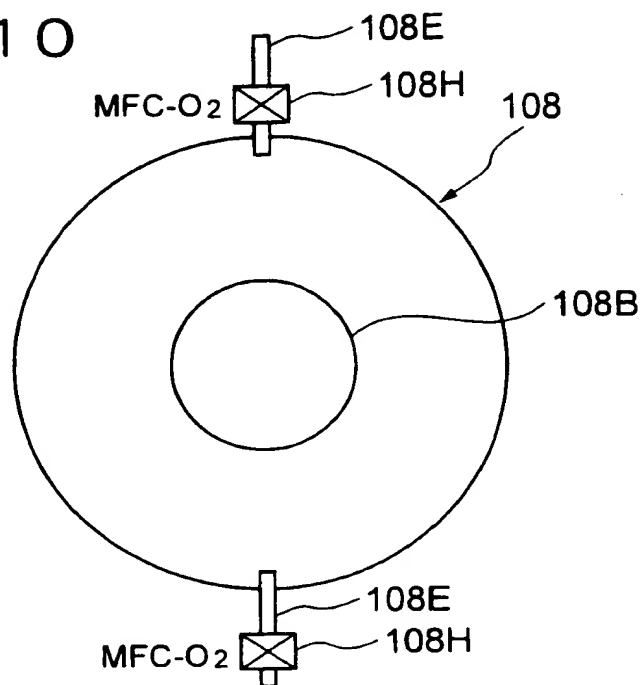
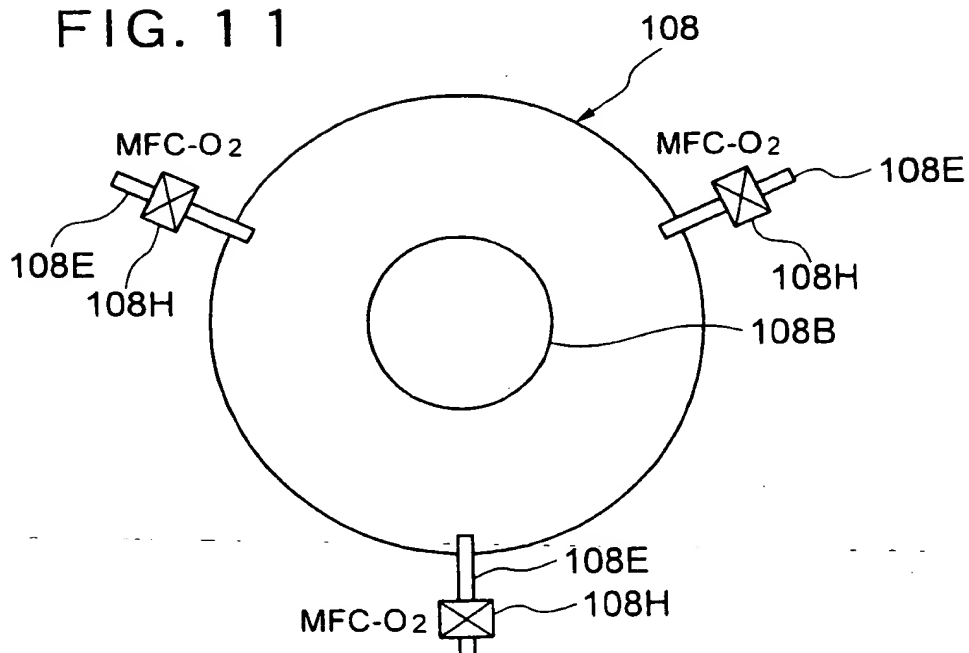


FIG. 11



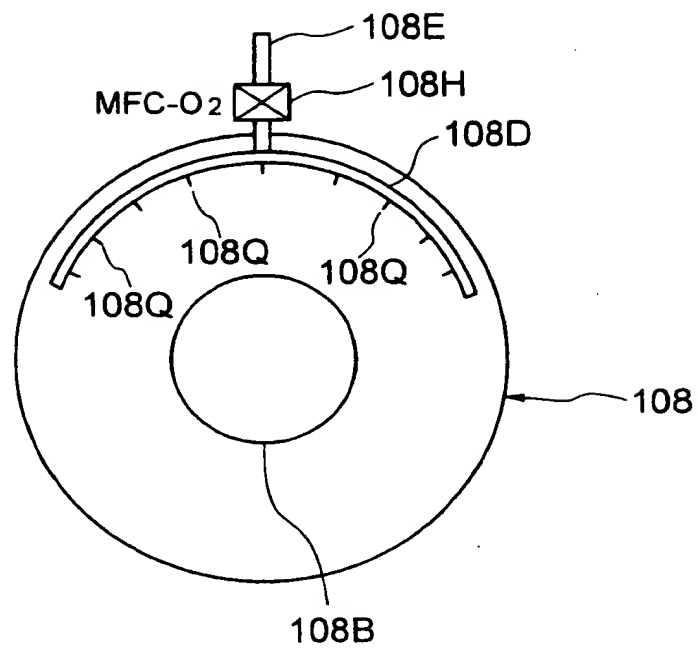


FIG. 12

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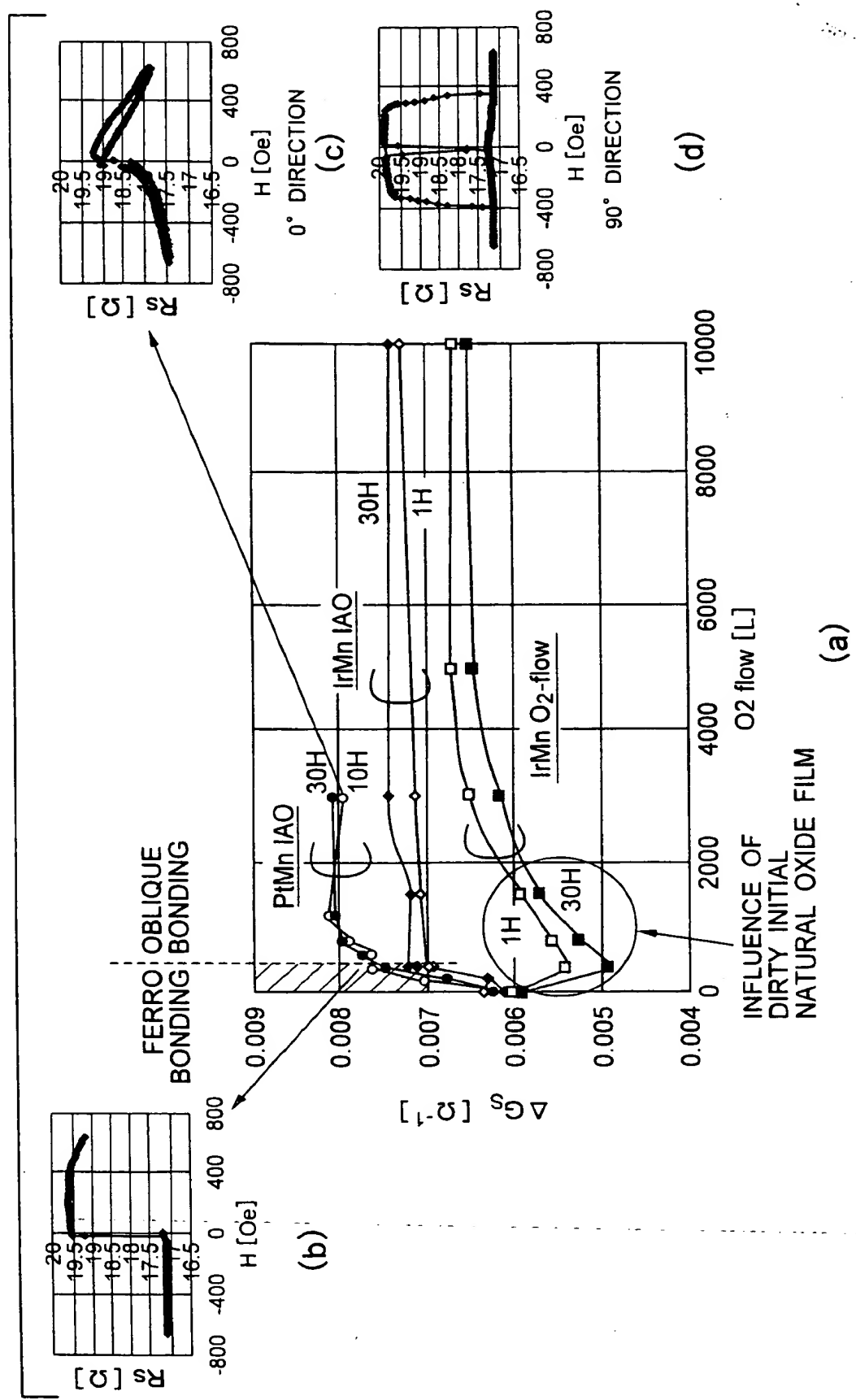


FIG. 13

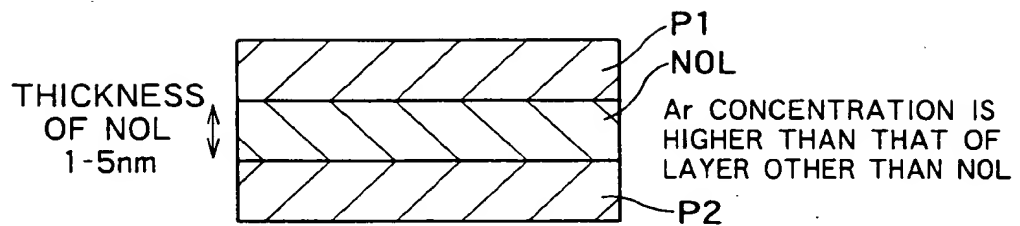


FIG. 14

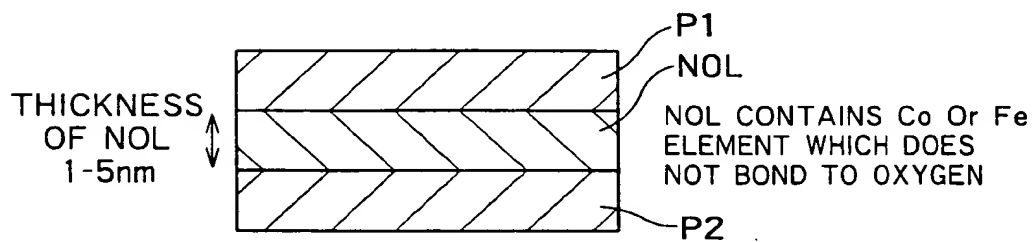


FIG. 15

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SENSE CURRENT



Free-NOL (1.5)
Spin-filter (Cu 1)
Free (CoFeNi 2)
Spacer (cu 2)
Pin (CoFe 2)
Pin-NOL (1.5)
Pin (CoFe 0.5)
Ru 0.9
Pin (CoFe 1.5)
Antiferro (PtMn 10)
Seed (NiFeCr 3)
Buffer (Ta 3)

FIG. 16

SENSE
CURRENT



Free-NOL (1.5)
Spin-filter (Cu 1)
Free (CoFeNi 2)
Spacer (Cu 2)
Pin (CoFe 2)
Pin-NOL (1.5)
Pin (CoFe 0.5)
Ru 0.9
Pin (CoFe 1.5)
Antiferro (PtMn 10)
Seed (NiFeCr 3)
Buffer (Ta 3)

FIG. 17

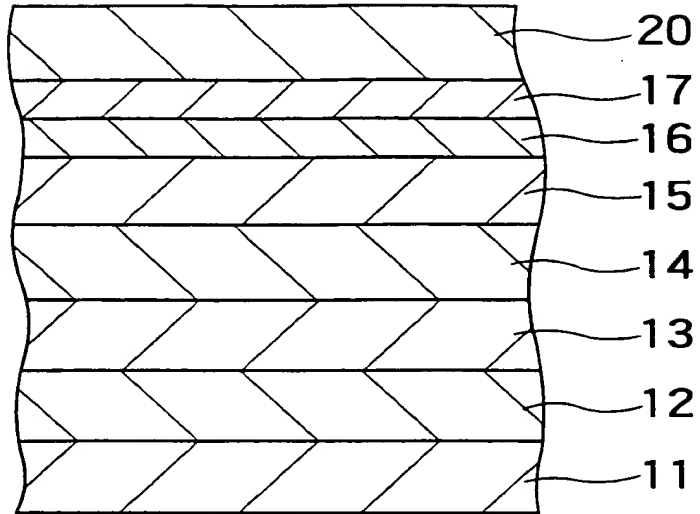


FIG. 18

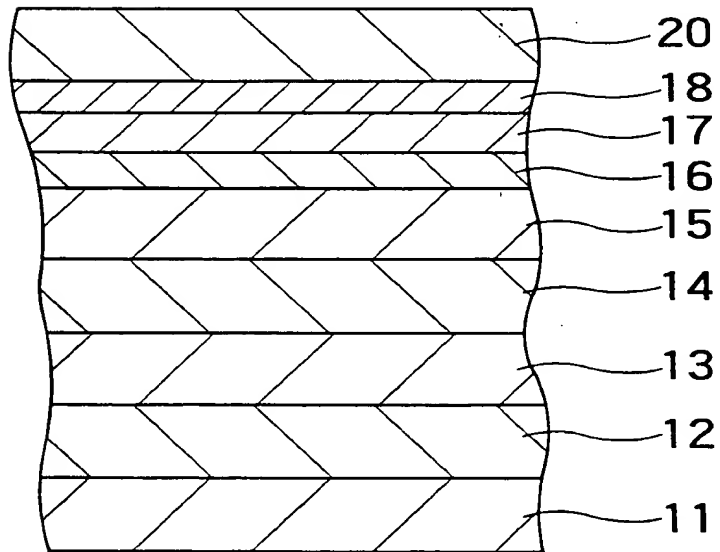


FIG. 19

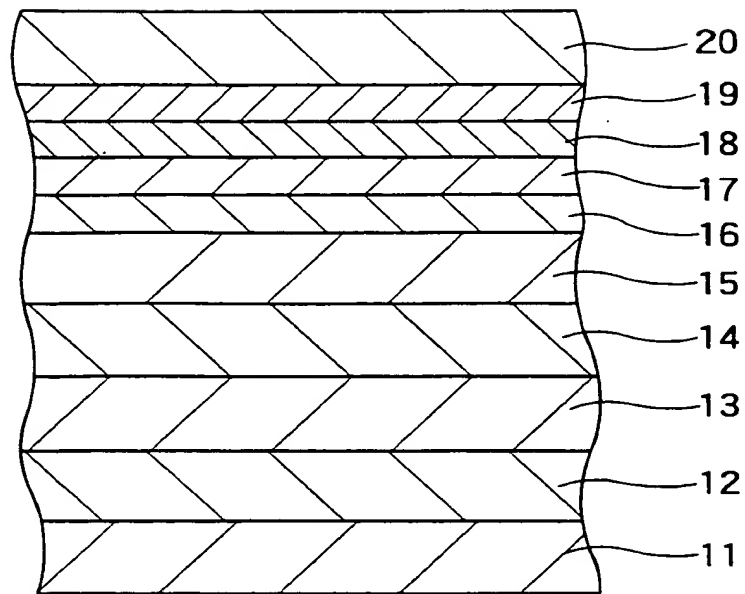


FIG. 20

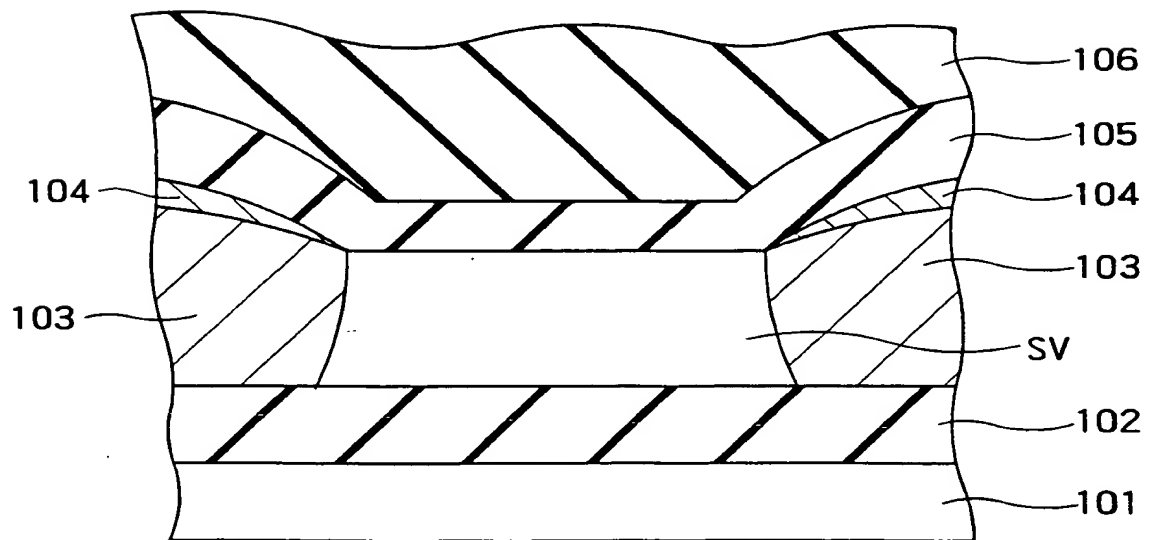


FIG. 21

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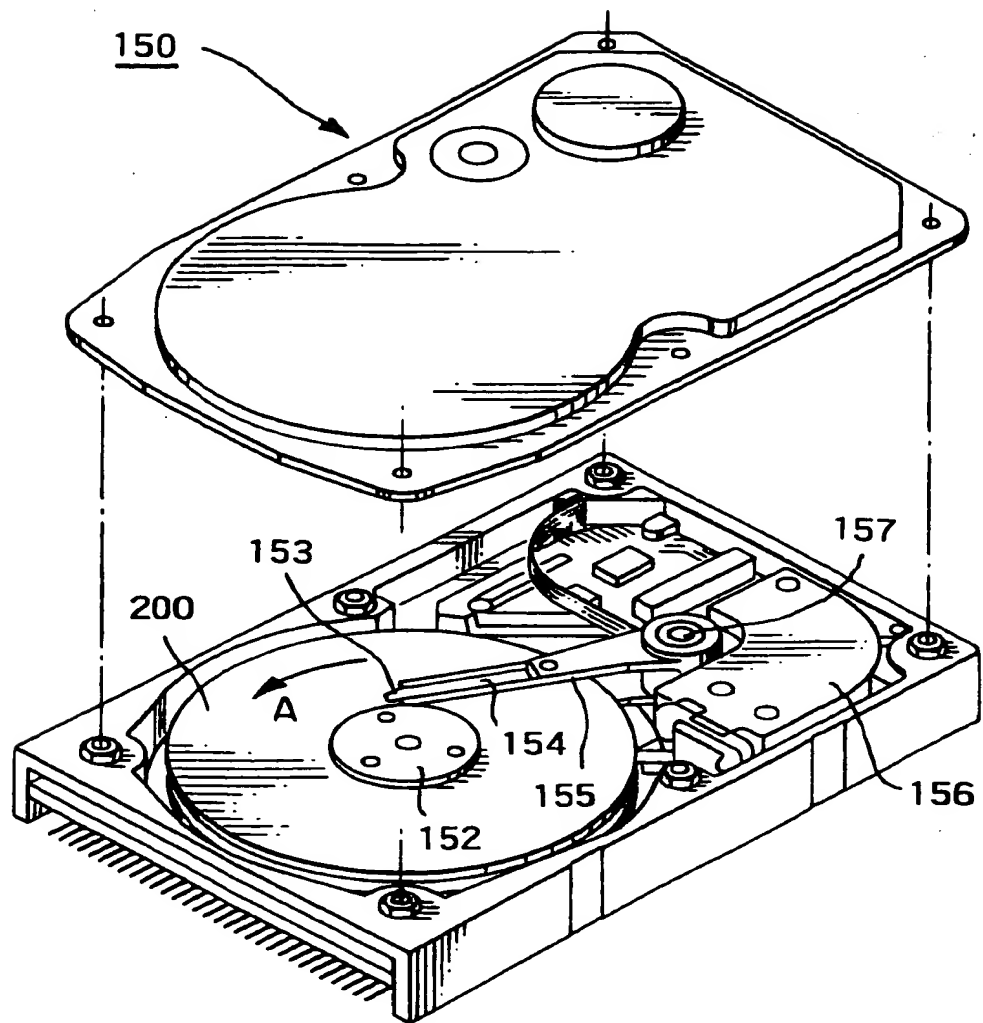


FIG. 22

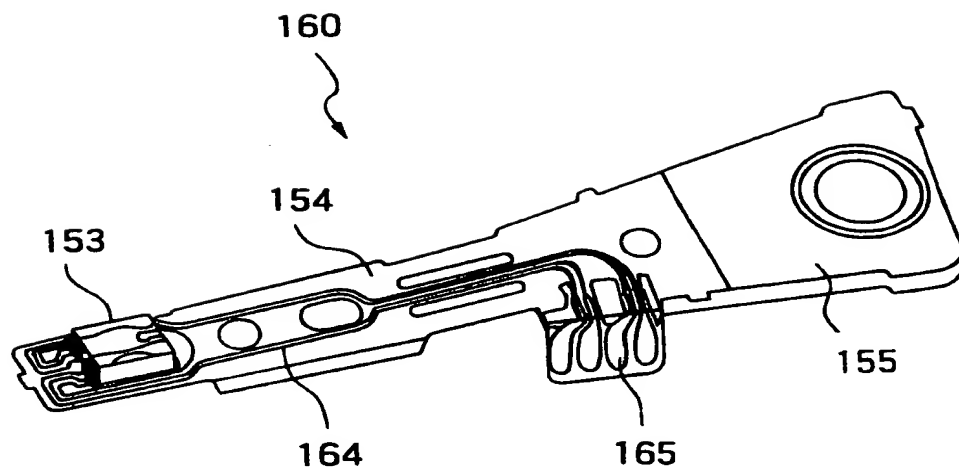


FIG. 23

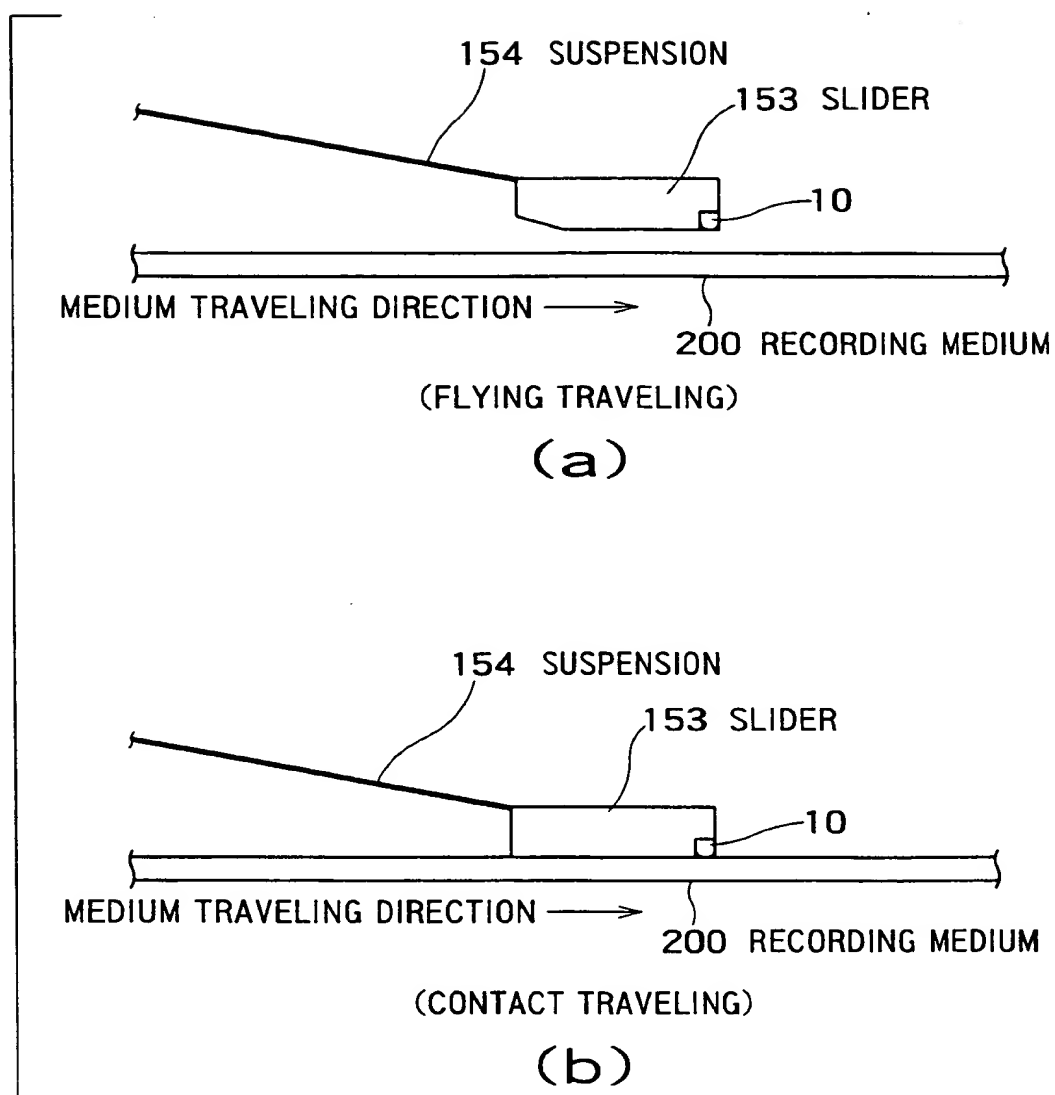


FIG. 24

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